EXPOSURE TO TOBACCO SMOKE IN SYDNEY, KUALA LUMPUR, EUROPEAN AND CHINESE CITIES

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Summary

Studies in eight European and four Asia Pacific cities have measured exposures to respirable suspended particles (RSP) and environmental tobacco smoke (ETS) for more than 2500 nonsmoking volunteers. Personal monitoring over 24-h periods took place in various locations. Nicotine exposures and saliva cotinine levels were analysed. RSP levels were highest in smoking workplaces and median levels for Sydney 34 $\mu g/m^3$, Beijing 128 $\mu g/m^3$, Basel 24 $\mu g/m^3$ and Kuala Lumpur 44 $\mu g/m^3$ were found. In smoking workplaces median levels of nicotine were below the limit of quantification in Sydney, 2.4 $\mu g/m^3$ in Barcelona and 2.1 $\mu g/m^3$ in Beijing. Annualised median exposures, expressed as cigarette equivalents (CEs), for subjects working with smokers were 0.2 CEs in Sydney, 1.4 CEs in Prague, 0.7 CEs in Hong Kong and 4.3 CEs in Barcelona. Benzene levels were highest in Beijing. Subjects in Malaysia and China considered themselves most exposed to ETS 'outside' whereas 'bars/restaurants' were chosen by subjects from all other cities. Misclassification of nonsmoking status varied from 1.6% in Turin to 19.6% in Barcelona.

Keywords: personal exposure, respirable suspended particles, environmental tobacco smoke, nicotine, cotinine, solanesol, cigarette equivalents.

1 Introduction

Studies using personal monitoring to measure respirable suspended particles (RSP) and environmental tobacco smoke (ETS) constituents have been undertaken by these authors based around eight major European and four Asia Pacific cities (Phillips *et al.* 1996, 1997a-b and 1998a-d). The studies involved volunteers monitoring air close to their breathing zone over 24-h periods. ETS particles were estimated from RSP using ultraviolet absorbing particulate matter (UVPM), fluorescing particulate matter (FPM) and solanesol related particulate matter (SolPM). Vapour phase ETS exposures were also assessed by simultaneous measurement of nicotine and 3-ethenylpyridine concentrations. Fixed site monitoring for volatile organic compounds (VOCs) inside and outside some of the subjects' homes was undertaken as part of these international studies. Studies with similar designs have also been reported for the United States (Jenkins *et al.* 1996) and Korea (Baek *et al.* 1997). These studies have provided much needed data on exposure in the workplace and outside the workplace, including the home.

For Sydney, a new protocol was designed to monitor volunteers only while at home, a second group only while at work, a third group whilst neither at work nor at home (ie 'elsewhere') and a fourth group who wore the monitor over a 24-h period irrespective of their location. Data from this study should compensate for deficiencies highlighted by the National Health and Medical Research Council Working Party on Passive Smoking (NHMRC) in November 1995.

2 Methods

The subjects who participated in these studies were recruited by established marketing agencies in each of the countries represented. A defined protocol was followed, where possible, to ensure a minimum number of 30 subjects in each defined category (Cell). Recruitment was also targeted for equal numbers in each of three age groups and, for office workers, an equal number of males and females. The participants were recruited from the nonsmoking population living within 15 km of the centre of each city. They were selected randomly by the marketing agency from a representative sample of each city's population held in their own databases.

Full details of the personal monitoring procedures and analytical methodologies applied in the eight European studies, and those in Hong Kong, Kuala Lumpur and Beijing, have been published elsewhere (Phillips *et al.* 1996). Briefly, the subjects were categorised as either 'housewives' or 'office workers' and were further subdivided into 6 Cells based upon the smoking status of their homes and/or workplaces. Housewives wore one personal monitor (Ogden *et al.* 1996, Figure 1) and

office workers two monitors (one at work and one at all other times) over a 24-h period. 24-h time weighted average (TWA) concentrations of all 'markers' were calculated for all subjects.

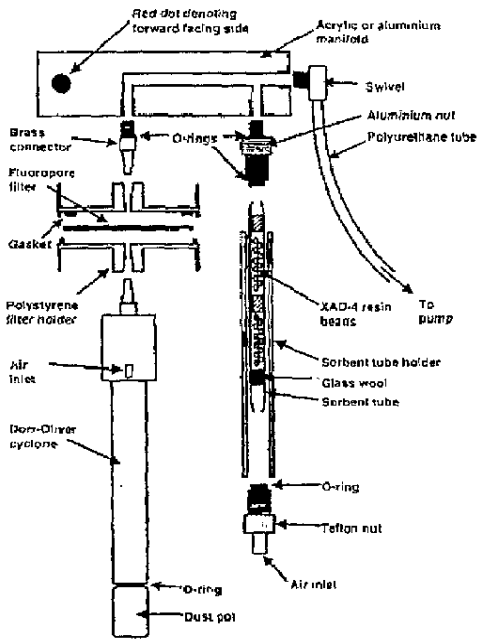

Figure 1. Personal Monitor.

The study in Sydney, using a modified protocol, has been described elsewhere (Phillips *et al.* 1998d). For all investigations, subjects were 'trained' in the use of the monitoring equipment and were shown a video in their own language to assist the process.

In order to compare findings across cities, data have been normalised as there were variable limits of quantification (LOQ) and different response factors for estimating ETS particles. Apportionment factors for ETS particle estimates were derived from studies conducted in a model room and the applied values were 43 (SolPM), 45 (FPM) and 8.2 (UVPM) as determined by Nelson *et al.* (1997). Approximately 10% of the housewives participating on the personal monitoring studies volunteered to have the inside and outside of their properties monitored for VOCs. VOCs were sampled (fixed site) using a briefcase adapted to carry pumps and attached adsorption tubes through which the ambient air was drawn over a 24-h period. Subsequent analysis of the adsorbent tubes was performed using thermal desorption followed by capillary gas chromatography, with quantification and identification by mass spectrometry. More than 30 individual VOCs were analysed on each occasion.

Responses provided on questionnaires were used to assign the subjects into Cells based upon the smoking status of their household and workplace. A household was classified as 'smoking' if a smoker of cigarettes, pipes or cigars was resident and also normally smoked within communal areas of the household. The smoking status of a workplace was defined by the absence/presence of smoking co-workers within 30 metres of the subject's workstation. These definitions were chosen for consistency and to best represent 'real world' situations across the different cities under study.

Table 1. Personal exposure concentrations (μg/m^3) measured in the workplace.

City	Smoking workplaces			Nonsmoking workplaces		
	RSP	ETS	Nicotine	RSP	ETS	Nicotine
Stockholm	<LOQ (46)	1.1 (8.3)	<LOQ (1.3)	<LOQ (45)	<LOQ (2.6)	<LOQ (0.30)
Barcelona	94 (197)	36 (128)	2.4 (9.0)	52 (90)	2.5 (28)	0.71 (2.0)
Turin	90 (172)	8.3 (73)	0.99 (5.4)	64 (100)	<LOQ (6.8)	0.41 (0.92)
Paris	63 (127)	4.5 (59)	1.0 (4.6)	53 (93)	1.4 (18)	0.33 (0.99)
Bremen	36 (105)	<LOQ (23)	0.27 (3.3)	<LOQ (45)	<LOQ (1.2)	<LOQ (0.28)
Lisbon	41 (135)	1.7 (52)	0.75 (6.8)	<LOQ (65)	<LOQ (20)	<LOQ (1.7)
Basel	24 (78)	1.4 (21)	0.27 (3.2)	<LOQ (77)	<LOQ (5.8)	<LOQ (<LOQ)
Prague	61 (151)	11 (82)	1.5 (8.2)	32 (78)	1.2 (14)	0.17 (1.3)
Hong Kong	51 (112)	5.9 (53)	0.52 (4.0)	38 (72)	0.36 (6.3)	<LOQ (0.32)
Kuala Lumpur	44 (88)	0.48 (9.6)	0.28 (2.2)	43 (92)	<LOQ (6.1)	<LOQ (0.54)
Sydney	34 (51)	1.5 (24)	<LOQ (2.9)	<LOQ (41)	<LOQ (<LOQ)	<LOQ (<LOQ)
Beijing	128 (261)	9.9 (83)	2.1 (10)	88 (205)	<LOQ (18)	0.14 (1.8)

Table 2. Personal exposure concentrations (μg/m^3) measured outside the workplace.

City	Smoking households			Nonsmoking households		
	RSP	ETS	Nicotine	RSP	ETS	Nicotine
Stockholm	24 (37)	1.6 (38)	0.15 (0.42)	19 (33)	<LOQ (1.6)	<LOQ (0.17)
Barcelona	85 (160)	21 (96)	0.86 (4.4)	40 (105)	2.2 (23)	0.17 (0.61)
Turin	63 (135)	14 (89)	0.97 (2.8)	46 (90)	0.68 (7.1)	0.19 (0.40)
Paris	61 (112)	7.7 (46)	0.68 (2.9)	31 (66)	<LOQ (1.6)	0.19 (0.34)
Bremen	37 (89)	1.1 (28)	0.40 (1.7)	22 (39)	<LOQ (0.82)	<LOQ (0.27)
Lisbon	41 (66)	0.51 (13)	0.21 (1.7)	26 (52)	<LOQ (1.4)	<LOQ (0.27)
Basel	29 (85)	1.4 (42)	0.38 (3.0)	24 (55)	<LOQ (13)	<LOQ (0.69)
Prague	50 (105)	4.6 (45)	0.78 (3.3)	27 (55)	0.43 (3.8)	<LOQ (0.42)
Hong Kong	60 (96)	0.81 (12)	0.31 (2.1)	45 (96)	<LOQ (1.9)	<LOQ (0.17)
Kuala Lumpur	48 (83)	<LOQ (2.8)	<LOQ (0.61)	42 (87)	<LOQ (0.71)	<LOQ (0.24)
Sydney ("*Home*")	30 (70)	0.92 (25)	0.30 (1.6)	24 (41)	<LOQ (0.27)	<LOQ (0.10)
Sydney("*Elsewhere*")	48 (120)	<LOQ (36)	<LOQ (5.1)	34 (73)	<LOQ (4.3)	<LOQ (0.94)
Beijing	101 (216)	4.2 (49)	0.97 (3.6)	88 (204)	0.81 (8.2)	0.21 (0.50)

3 Results and Conclusions

Median personal exposure concentrations determined in the workplace throughout all 12 cities are listed in Table 1, with the 90th percentile concentrations shown in parentheses. Data below the LOQ are also indicated. A total of 2574 subjects participated in these studies.

The ETS concentrations listed are based on calculations using solanesol (Ogden *et al.* 1990) to estimate ETS particle contributions to total RSP. In all cities the highest median concentrations for RSP, ETS particles and nicotine were found in the workplaces where smoking was allowed. For Sydney, analyte levels in smoking workplaces were amongst the lowest measured in any city and in nonsmoking workplaces ETS particles and nicotine were not quantifiable, even at 90th percentile levels.

Concentrations measured outside the workplace, at home and elsewhere are listed in Table 2. Sydney, Stockholm and Bremen had the lowest median RSP levels. In the 'elsewhere' group in Sydney, nonsmokers living with smokers were exposed to higher concentrations outside work and the home than those living with nonsmokers. These findings appear to indicate that these two groups of nonsmokers have different lifestyles. Nonsmokers living with smokers may be more likely to accompany their spouse and visit locations with a smoky atmosphere. It is also possible that nonsmokers living with nonsmokers deliberately avoid locations where smoking occurs.

Table 3. 24-h time weighted average personal exposure concentrations for subjects from smoking households.

City	RSP (μg/m^3)		ETS (μg/m^3)		Nicotine (μg/m^3)	
	Housewives	Workers	Housewives	Workers	Housewives	Workers
Stockholm	39 (77)	19 (39)	19 (64)	3.3 (31)	1.0 (6.7)	0.18 (1.3)
Barcelona	63 (155)	100 (143)	11 (86)	34 (81)	0.74 (2.8)	1.7 (3.9)
Turin	71 (140)	79 (129)	6.1 (55)	17 (88)	1.1 (4.9)	1.2 (4.0)
Paris	62 (130)	74 (117)	3.2 (53)	12 (52)	0.52 (2.4)	1.1 (3.7)
Bremen	36 (63)	35 (80)	<LOQ (7.7)	1.6 (27)	0.49 (1.5)	0.52 (1.7)
Lisbon	38 (67)	35 (63)	<LOQ (11)	4.2 (20)	0.19 (1.2)	0.53 (3.0)
Basel	34 (88)	29 (82)	1.4 (22)	4.0 (34)	0.60 (1.5)	0.68 (3.3)
Prague	48 (112)	55 (128)	5.7 (44)	9.9 (46)	0.72 (3.1)	1.2 (4.9)
Hong Kong	45 (77)	50 (80)	<LOQ (0.84)	2.5 (18)	<LOQ (0.51)	0.30 (3.0)
Kuala Lumpur	52 (89)	51 (81)	<LOQ (3.8)	1.6 (7.8)	0.18 (1.3)	0.22 (1.2)
Sydney	21 (44)		3.7 (19)		0.39 (1.4)	
Beijing	102 (221)	103 (225)	8.3 (67)	7.5 (53)	1.3 (3.6)	1.3 (4.0)

Table 4. 24-h time weighted average personal exposure concentrations for subjects from nonsmoking households.

City	RSP ($\mu g/m^3$) Housewives	RSP ($\mu g/m^3$) Workers	ETS ($\mu g/m^3$) Housewives	ETS ($\mu g/m^3$) Workers	Nicotine ($\mu g/m^3$) Housewives	Nicotine ($\mu g/m^3$) Workers
Stockholm	18 (34)	18 (32)	<LOQ (2.6)	0.32 (3.1)	<LOQ (0.86)	<LOQ (0.36)
Barcelona	51 (90)	60 (115)	0.98 (7.9)	16 (77)	0.11 (0.46)	1.0 (3.7)
Turin	54 (81)	57 (98)	0.43 (2.7)	2.1 (17)	0.14 (0.60)	0.32 (1.2)
Paris	36 (84)	42 (71)	0.62 (2.8)	1.6 (10)	0.13 (0.29)	0.40 (1.0)
Bremen	25 (37)	25 (47)	<LOQ (0.88)	<LOQ (8.0)	<LOQ (0.22)	0.12 (0.74)
Lisbon	38 (54)	36 (65)	<LOQ (0.22)	0.78 (16)	<LOQ (0.31)	0.18 (2.0)
Basel	28 (49)	26 (74)	<LOQ (1.4)	0.81 (13)	<LOQ (0.31)	<LOQ (0.97)
Prague	32 (55)	37 (66)	<LOQ (4.0)	2.8 (27)	0.15 (0.51)	0.39 (1.6)
Hong Kong	46 (70)	46 (94)	<LOQ (0.21)	0.98 (8.0)	<LOQ (0.27)	<LOQ (0.41)
Kuala Lumpur	48 (89)	42 (84)	<LOQ (0.71)	<LOQ (3.1)	<LOQ (0.24)	<LOQ (0.56)
Sydney	21 (50)		<LOQ (0.43)		<LOQ (0.16)	
Beijing	70 (161)	99 (193)	0.55 (2.9)	2.7 (26)	0.15 (0.72)	0.45 (2.1)

The median (90^{th} percentile in parentheses) 24-h TWA concentrations for RSP, ETS particles and nicotine are presented in Tables 3 and 4 for subjects from smoking and nonsmoking homes respectively. For Sydney, these data were only available for one group of subjects, whereas in all other cities they have been reported for both housewives and office workers. For all subjects, RSP levels were highest in Beijing and were lowest in Sydney and Stockholm.

24-h TWA levels of nicotine and ETS particles were highest for office workers living with smokers in Barcelona. For subjects living with smokers in Sydney, ETS particle and nicotine levels were approximately midway in the range found for the cities studied.

In most cities, including Sydney, median 24-h TWA data for ETS particles and nicotine were below the LOQ for subjects from nonsmoking homes. The exceptions were Barcelona, Turin, Paris and Beijing where all median data were greater than the LOQ.

The term 'potential inhaled quantity' (PIQ) is used in this publication as a measure of 'overall exposure' and was calculated as the product of the analyte concentration, the length of time subjected to the concentration and a typical average breathing rate of 0.85 m^3/h (Holcomb 1993). Table 5 lists these PIQs for the workplace, calculated on the basis of a 35-h, 48 week working year, in terms of cigarette equivalents (CEs), a concept used to assist in the assessment of ETS exposures.

Table 5. Annualised PIQs in smoking workplaces (cigarette equivalents).

City	Median levels (SolPM / nicotine)	90^{th} percentile (SolPM / nicotine)
Stockholm	0.13 / na	0.99 / 1.8
Barcelona	4.3 / 3.4	15 / 13
Turin	0.99 / 1.4	8.7 / 7.7
Paris	0.54 / 1.4	7.0 / 6.6
Bremen	na / 0.38	2.7 / 4.7
Lisbon	0.20 / 1.1	6.2 / 9.4
Basel	0.16 / 0.39	2.5 / 4.6
Prague	1.4 / 2.2	9.7 / 12
Hong Kong	0.70 / 0.74	6.3 / 5.7
Kuala Lumpur	0.06 / 0.40	1.1 / 3.1
Sydney	0.18 / na	2.9 / 4.1
Beijing	1.2 / 3.0	9.9 / 14

Based on median levels of ETS particles (SolPM) only office workers in Barcelona, Prague and Beijing working in smoking offices would be exposed to more than 1 CE per annum. The lowest median PIQs were estimated in Kuala Lumpur, followed by Stockholm and Sydney. When comparing 90^{th} percentile CEs Stockholm, Bremen, Basel, Kuala Lumpur and Sydney office workers would receive less than 3 CEs per annum.

To ensure all the subjects from each city were nonsmokers, saliva samples were taken before and after the 24-h monitoring period. The samples were subsequently analysed for cotinine, a main metabolite of nicotine. Subjects with cotinine levels greater than 25 ng/ml, in either sample, had their data removed from the database. These subjects were considered to have misreported their nonsmoking status. The misclassification rates (Table 6) varied from less than 6.5% in 9 of the 12 cities to more than 18% in Lisbon and Barcelona. The highest median cotinine levels were below 3 ng/ml and close to or below the LOQ in Sydney and Kuala Lumpur.

Table 6. Misclassification rates and highest median cotinine levels (ng/mL).

City	Misclassification rate (%)	Pre-cotinine	Post-cotinine
Stockholm	2.7 - 5.3	2.9	2.9
Barcelona	11.0 - 19.6	1.6	1.8
Turin	1.6 - 6.5	1.7	1.5
Paris	1.8 - 4.7	1.5	1.6
Bremen	2.6	1.5	1.7
Lisbon	17.9 - 18.3	2.1	1.7
Basel	9.7 - 12.2	2.5	2.0
Prague	1.7 - 2.5	2.5	2.5
Hong Kong	5.4 - 6.3	1.3	1.3
Kuala Lumpur	3.2 - 4.0	<LOQ	1.1
Sydney	1.8 - 2.8	1.0	<LOQ
Beijing	2.7	1.8	1.8

At median levels benzene concentrations were highest both indoors and outdoors in Beijing (Table 7). Beijing also had the highest FPM levels likely to have been due to pollutants derived from combustion sources using fossil fuel. Median toluene levels in all cities were the highest of all VOCs measured in these studies. 1,3-Butadiene is categorised similar to benzene as a potential leukaemia inducing agent or carcinogen and was found both indoors and outdoors in all cities (Table 8). Significantly higher levels were found in Paris, Turin and Hong Kong, with the most likely source being road traffic emissions. There was no significant difference at median levels between the VOC concentrations monitored in smoking compared with nonsmoking households.

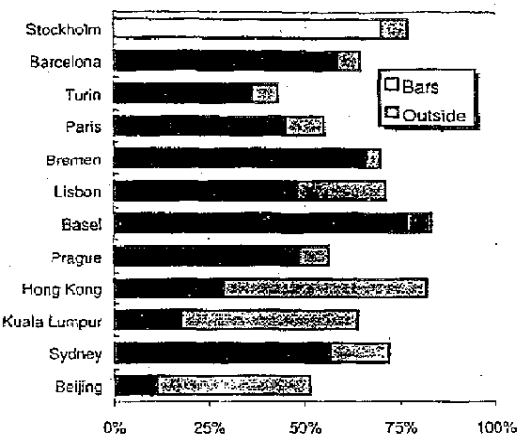

Figure 2. Highest exposure location (subjective).

The volunteers were asked 'In which location do you think that you are exposed to the most tobacco smoke in the air?' The answers provided are depicted in Figure 2. In European cities, bars and restaurants were perceived by most subjects as the location with the highest ETS exposure. In Beijing, Kuala Lumpur and Hong Kong most subjects answered 'outside' (including travelling) to this question. This suggests that a different lifestyle exists in Asia Pacific cities compared with Sydney and European cities.

Table 7. Benzene and toluene median (90th percentile) concentrations

	Benzene ($\mu g/m^3$)			Toluene ($\mu g/m^3$)		
City	Indoors Smoking	Indoors Nonsmoking	Outdoors	Indoors Smoking	Indoors Nonsmoking	Outdoors
Turin	6.0 (10)	7.7 (9.8)	4.5 (8.0)	9.0 (17)	6.3 (12)	5.1 (14)
Paris	5.3 (12)	3.3 (8.8)	3.4 (8.5)	12 (33)	6.9 (20)	11 (15)
Bremen	2.9 (6.9)	1.5 (3.0)	1.1 (1.7)	20 (47)	20 (60)	4.0 (7.1)
Lisbon	0.88 (5.4)	1.7 (6.0)	1.3 (6.8)	4.4 (57)	12 (37)	9.1 (40)
Basel	1.4 (2.9)	3.6 (13)	1.0 (9.1)	55 (97)	50 (119)	20 (29)
Prague	1.6 (2.8)	0.60 (1.3)	4.0 (5.0)	37 (53)	18 (42)	14 (23)
Hong Kong	3.3 (5.9)	3.4 (6.0)	3.2 (6.4)	35 (115)	38 (65)	33 (66)
Kuala Lumpur	6.1 (18)	4.6 (16)	9.8 (20)	47 (77)	48 (73)	49 (80)
Sydney	2.3 (4.2)	3.4 (6.5)	3.7 (7.8)	20 (65)	19 (36)	17 (30)
Beijing	15 (34)	11 (32)	16 (20)	44 (103)	25 (271)	31 (62)

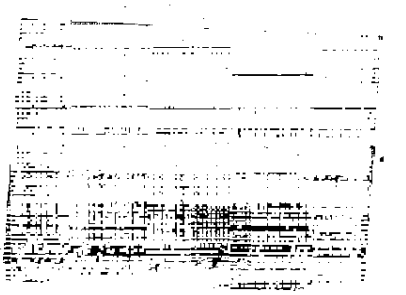

Table 8. 1,3-Butadiene and Isoprene median (90th percentile) concentrations.

City	1,3 Butadiene (µg/m^3)			Isoprene (µg/m^3)		
	Indoors Smoking	Indoors Nonsmoking	Outdoors	Indoors Smoking	Indoors Nonsmoking	Outdoors
Turin	4.3 (5.6)	1.7 (3.6)	1.4 (2.5)	5.8 (25)	3.1 (5.5)	1.2 (2.8)
Paris	19 (29)	10 (41)	5.5 (8.5)	8.2 (31)	3.2 (6.1)	1.4 (3.3)
Bremen	4.7 (23)	3.4 (7.7)	0.18 (6.5)	43 (147)	3.1 (15)	0.19 (0.50)
Lisbon	0.74 (6.3)	2.2 (7.1)	1.5 (9.0)	0.07 (3.3)	0.86 (9.0)	0.22 (2.7)
Basel	0.43 (0,59)	1.1 (2.7)	0.88 (5.3)	0.08 (0.23)	0.25 (1.1)	0.09 (0.41)
Prague	0.62 (1.1)	0.46 (2.4)	0.54 (1.3)	0.34 (1.2)	0.66 (0.99)	0.31 (0.60)
Hong Kong	2.3 (8.5)	2.4 (10)	3.6 (10)	0.51 (1.0)	0.57 (1.1)	0.53 (0.65)
Kuala Lumpur	0.39 (1.4)	0.40 (0.97)	0.41 (1.4)	0.11 (0.97)	0.08 (0.85)	0.05 (0.76)
Sydney	0.14 (0.72)	0.12 (0.54)	0.13 (0.32)	0.19 (0.46)	0.16 (0.38)	0.12 (0.25)
Beijing	0.20 (0.71)	0.28 (0.59)	0.16 (0.57)	0.86 (3.7)	0.78 (1.2)	0.74 (2.0)

4 Acknowledgement

The funding for all of these studies was made available to Covance Laboratories Ltd. by the Center for Indoor Air Research (CIAR), Linthicum, MD, USA.

5 References

Baek S-O., Kim Y-S., Perry R. 1997. 'Indoor air quality in homes, offices and restaurants in Korean urban areas - indoor/outdoor relationships', *Atmospheric Environment* 31:529-544.

Holcomb L.C. 1993, 'Indoor air quality and environmental tobacco smoke: concentration and exposure', *Environ Int* 19:9-40.

Jenkins R.A., Palausky A., Counts R.A., Bayne C.K., Dindal A.B., Guerin M.W. 1996, 'Exposure to environmental tobacco smoke in sixteen cities in the United States as determined by personal breathing zone air sampling', *J Exp Anal Environ Epidemiol* 6:473-502.

Nelson P.R., Conrad F.W., Kelly S.P., Maiolo K.C., Richardson J.D., Ogden M.W. 1997, 'Composition of environmental tobacco smoke (ETS) from international cigarettes and determination of ETS-RSP: Particulate marker ratios', *Environ Int* 23:47-52.

Ogden M.W., Maiolo K.C., Oldaker G.B., Conrad F.W. 1990, 'Evaluation of methods for estimating the contribution of ETS to respirable suspended particles', *Proceedings of the International Conference on Indoor Air Quality and Climate, Ottawa 1990*: in Walkinshaw DS (ed) *Indoor Air* 90(2):415-420.

Ogden M.W., Heavner D.L., Foster T.L., Maiolo K.C., Cash S.L., Richardson J.L., Martin P., Simmons P.S., Conrad F.W., Nelson P.R. 1996, 'Personal monitoring system for measuring environmental tobacco smoke exposure', *Environ Technol* 17:239-250

Phillips K., Bentley M.C., Howard D.A., Alván G. 1996, 'Assessment of air quality in Stockholm by personal monitoring of nonsmokers for respirable suspended particles and environmental tobacco smoke', *Scand J Work Environ Health* 22 **Suppl** 1:1-24.

Phillips K., Bentley M.C., Howard D.A., Alván G., Huici A. 1997a, 'Assessment of air quality in Barcelona by personal monitoring of nonsmokers for respirable suspended particles and environmental tobacco smoke', *Environ Int* 23(2):173-196.

Phillips K., Howard D.A., Bentley M.C., Alván G. 1997b, 'Assessment of air quality in Turin by personal monitoring of nonsmokers for respirable suspended particles and environmental tobacco smoke', *Environ Int* 23(6):851-871.

Phillips K., Bentley M.C., Howard D.A., Alván G. 1998a, Phillips K., Howard D.A., Bentley M.C., Alván G. 1998a, 'Assessment of air quality in Paris by personal monitoring of nonsmokers for respirable suspended particles and environmental tobacco smoke', *Environ Int* 24(4):405-425.

Phillips K., Howard D.A., Bentley M.C., Alván G. 1998b, 'Measured exposures by personal monitoring for respirable suspended particles and environmental tobacco smoke of housewives and office workers resident in Bremen, Germany', *Int Arch Occup Environ Health* 71(3):201-221.

Phillips K., Howard D.A., Bentley M.C., Alván G. 1998c, 'Assessment of environmental tobacco smoke and respirable suspended particle exposures for nonsmokers in Lisbon by personal monitoring', *Environ Int* 24(3):301-324.

Phillips K., Howard D.A., Bentley M.C., Alván G. 1998d, 'Assessment by personal monitoring of respirable suspended particles and environmental tobacco smoke exposure for nonsmokers in Sydney, Australia', *Indoor and Built Environment* (In press).